

years an ample supply of those who prefer to remain ignorant and uncultured to satisfy all demands. In the noble address delivered by Prof. Huxley at Belfast, he insisted, with all the force of his calm eloquence, on the folly of making a bugbear of logical consequences; and in no science is there more need for this exhortation than in that of education. Mrs. Grey well put it that no education is worthy of the name that does not at least aim at a right training of the three departments of the mind—the reasoning faculties to determine the right from the wrong, the emotional to follow the right when found, and the imaginative to conceive the perfect ideal of all goodness. In determining a course of education, whether for boys or girls, when we have once satisfied ourselves that our principles are sound, let us unhesitatingly follow them out, letting the possible consequences take care of themselves; and we may feel sure that the conclusions to which we shall be led will stand the test of experience.

The point which we think should be most prominently brought forward by the advocates of a reform in female education is not so much the desirableness of turning its future current in any one direction, as the necessity for removing all trammels and barriers raised by man's ignorance or prejudice. On this ground we sympathise most heartily in all the efforts now being made to widen the basis of the education of women, whether in the way of special colleges, university examinations, or courses of lectures involving severe study. Let us first of all—divesting ourselves of all preconceived theories on the subject, whether social, metaphysical, or physiological—give free scope to the faculties of woman before we begin to dogmatise on the extent to which these faculties will bear cultivation. Natural Selection will point out the occupations in which the female mind will excel; and the Survival of the Fittest will determine the professions in which woman can successfully compete with man. And every one who believes that faculties were originally endowed or gradually evolved for the purpose of being used, and powers for the sake of being exercised, must rejoice at every fresh extension of the field in which they may be employed.

DE BOISBAUDRAN ON SPECTRES LUMINEUX

Spectres Prismatiques et en Longueurs d'Ondes destinés aux Recherches de Chimie Minérale. Par M. Lecoq de Boisbaudran, avec Atlas des Spectres. (Paris: Gauthier-Villars, 1874).

THE spectrum maps of Kirchhoff, Huggins, Angström, and Thalen are so complete that little has been left for later observers except the filling up of some details. Angström's discovery that the bright lines which form the spectrum of the electric spark are partly due to the air or other gaseous medium traversed by the spark, partly to the vapour of the metallic poles, formed an epoch in the history of spectrum analysis; and the publication of the fine map of the solar spectrum by Kirchhoff (founded on the great original work of Fraunhofer), in which the positions of a large number of the metallic lines are carefully laid down, gave a great impulse to the pursuit of this branch of physical science. For the discovery of the new metals, cæsium, rubidium, thallium, and

indium, we are indebted to spectroscopic analysis. In a paper communicated to the Royal Society in 1863, Mr. Huggins gave a valuable map of the bright lines of the metals, as seen through a system of prisms adjusted for a minimum deviation of the line *D* of Fraunhofer. This was followed by the works of Thalen and Mascart, in which the positions of the metal lines are given in wave-lengths. The results obtained by Thalen are incorporated in the great work of Angström on the solar spectrum.

To observe the metal lines, the method usually employed is to pass the spark from a Ruhmkorff's machine, having a condenser connected with the fine wire, between poles of different metals. The air lines which come into view at the same time are easily distinguished by well-known characters from the metal lines, and were used by Mr. Huggins to fix the positions of the latter. In some cases the metal lines were obtained by drawing sparks from solutions of the chlorides.

In the work of M. Lecoq de Boisbaudran, two methods are chiefly followed for obtaining the spectra of the elements and of certain compound bodies. The first is the ordinary method of heating the body in the flame of a Bunsen burner; the second is to pass short electrical sparks from a Ruhmkorff's coil, *without condenser*, between a solution of the chloride of the metal and a fine platinum wire suspended above the solution. In the latter case the following is the method of experimenting usually employed by him:—The metallic solution is contained in a short glass tube, into the lower end of which a platinum wire is hermetically sealed. Another wire of platinum, or, still better, of iridium, attached to an insulating support, is adjusted at a distance of two or three millimetres from the surface of the liquid. An essential condition to the success of the experiment is to make the free wire positive, and the liquid negative. If this condition is reversed, the spectrum of the solution seldom appears, but is replaced by the ordinary air spectrum. In some cases, as with the alkaline salts, a fine spectrum is obtained by passing sparks between a fused bead of the salt and a platinum wire heated to redness in a Bunsen or spirit flame. According to M. Lecoq de Boisbaudran, the spectrum produced in this way is not only more brilliant, but is richer in metallic lines than that of the solution. The method of taking sparks in air between metallic poles has been employed in the work before us only in the cases of aluminium and lead. The spectro-scope employed was formed of a single prism of heavy glass, with a collimator, and telescope moveable on a graduated arc. An illuminated scale, projected from the anterior surface of the prism, was seen above the spectrum, and its indications were reduced to wave-lengths by comparison with the wave-lengths of certain solar and metallic lines, as determined by Fraunhofer, Mascart, Angström, and Thalen.

In a series of twenty-eight finely-executed engravings, M. Lecoq de Boisbaudran has given delineations of the spectra of a large number of bodies referred to the arbitrary scale of his spectro-scope, and also in wave-lengths. Except in a few cases, he has not attempted to represent the feebly illuminated ground or continuous spectrum which in many instances extends over nearly the whole field of view. But the characters of the bright lines and

bands are carefully represented, and a full description of them is given in the body of the work. The whole is designed to facilitate the application of spectrum analysis to mineral chemistry; and although some of the details may hereafter require correction, the work is well executed, and cannot fail to be of great value to the scientific and practical chemist. The frequent reproduction of the comparatively simple spectra of the metals obtained at the low temperature of the gas flame in elementary works of chemistry, unaccompanied by sufficient explanation, has tended to give rise to partial and even incorrect conceptions of the grandeur and extent of this subject. How many persons believe that the spectrum of sodium consists solely of a pair of fine lines corresponding to the double line *D* of the solar spectrum? How few know that at the high temperature of the electrical spark it exhibits three other pairs of well-defined lines, one in the orange, another in the yellow, and another in the green, together with a nebulous band on the confines of the blue? (Huggins). All these lines may easily be seen by passing the electrical spark in a non-luminous flame between a fused bead of sulphate or chloride of sodium and a platinum wire, together with a few other feeble lines, especially in the violet (Lecoq de Boisbaudran). The vivid line in the red, with its faint companion in the orange, which forms the ordinary spectrum of the compounds of lithium in the gas flame, gives place to a very different spectrum, when sparks are drawn from a solution of the lithium salts. The red ray still continues vivid, but it is surpassed in intensity by the orange, which is now the most characteristic of the lithium rays, while two new rays or lines come into view (λ 497'0, 460'4). With a solution either of the ferrous or ferric chloride, the electrical spark gives the numerous lines with great sharpness and accuracy of detail, which constitute the spectrum of metallic iron.

M. Lecoq de Boisbaudran gives a delineation of what he considers to be the spectrum of oxide of barium, as it appears after a prolonged heating of the chloride in the gas flame, and also of the spectra proper of the chloride, bromide, and iodide of barium, as obtained by heating those salts in the gas flame charged with hydrochloric acid, bromine, and iodine vapours respectively. These spectra are all different. Thus, in the case of the chloride, only slight traces of the lines and bands due to the oxide are seen, while six new lines appear which are very intense (A. Mitscherlich). On the interesting subject of the bright lines which compose the spectrum of the earth erbia and its phosphate, the following observations are made in the work before us:—"According to Bunsen and Bahr, the addition of a little phosphoric acid to solid erbia gives to that earth a greater emissive power and renders the lines sharper, without modifying their number or position. On repeating this experiment, I find that erbia alone and erbia to which phosphoric acid has been added give very different spectra. On comparing the spectra, the red is more developed in the light of the phosphate, whilst the green and the violet-blue are more vivid in that of the oxide."

The limits of this notice do not permit the discussion of questions of great interest in spectrum analysis, many of which promise soon to be fully resolved. The observation of Roscoe and Upton, that the broad bands characteristic

of certain metallic compounds at the low temperature of the gas flame disappear at the higher temperature of the electrical discharge, and the view they have set forth, that in the former case the spectrum is that of the compound, in the latter case that of the metal, have received confirmation from later researches. Lockyer, in his valuable contributions to spectrum analysis, has shown that what he designates the shortest lines disappear first on reducing the pressure, and that the difference between the spectrum of the chloride and the spectrum of the metal is that under the same spark condition all the short lines are obliterated in the former case. The same investigator has observed that metallic elements of low specific gravity, such as sodium, calcium, magnesium, and aluminium widen their lines by increase of vapour density, while metallic elements of high specific gravity, such as iron, cobalt, and nickel, increase under the same condition the number of their lines.

THOMAS ANDREWS

OUR BOOK SHELF

Comets and the New Comet of 1874. By the Author of "Astronomy Simplified for General Reading." (London: William Tegg and Co., 1874.)

THIS book purposes to be "a complete popular account of all that is known of these wonderful bodies which are so great a perplexity to science;" but the work consists of only 56 pages, and it is needless to say that even a popular account of these bodies to be complete must extend over a much larger space. We think that a work on any subject in science, to be popular, that is written to be read by the public at large and not by persons who are conversant with the subject only, should not refer to explanations or theories that are not generally known, without a very intelligible explanation; theories of the action of observed phenomena should not be given without a very strong probability of their truth, or without a caution against their acceptance; and in dealing with a subject like the present one, when our knowledge is limited, and when there are so many different modes of explaining appearances, it behoves an author to use more than ordinary caution against the mention of anything that is not strictly in accordance with ascertained physical laws. On both these points the present book is at fault. As an instance, the author mentions M. Faye's theory of the repulsive power of the sun in virtue of its heat, and then urges objections to the theory without a word of explanation of it. Now to a person not conversant with the experiments on the repulsion of gases and solids by heat rays, the theory would seem absurd and contrary to experience; and so the author carries the day with the theory that the effect of solar heat upon the cometary matter is electrical in its action. Again, he says: "For example, the matter of comets is not possessed of concentric attraction even with reference to itself, neither is it possessed of chemical affinity for itself. This is fully established by the eccentric forms of comets and through conspicuous variations of shape and size." This is quite new to us. Again, after mentioning that Lexell's comet was entangled for about a month among the satellites of Jupiter, he says: "Is there another instance—a single analogy on record outside of cometary phenomena—of a body of dead matter under great velocity being actually barred and stopped in its path for four months, and then suddenly starting off again after being divested of its force for so long a period? What can the composition and resolution of forces do for us here? for here is the most wonderful problem ever submitted to their laws. What must be the amazing force of a body which, like an